

Introduction

Livestock agriculture has undergone a striking transformation. Today, meat and dairy products typically originate on farms whose herds of cattle or hogs, or flocks of chickens, are much larger than in the past. These enterprises usually house a single species in buildings or in open-air pens, and provide them with feed that has been purchased rather than grown onsite. While most such farms are family owned and operated, they rely heavily on hired labor and are tightly linked to other stages of production and processing through formal contracts, alliances, and joint financing or common ownership of assets.

Most large dairy farms encompass several stages of production—in addition to producing milk, most still grow at least some of their own feed, produce and raise replacement heifers, and market dairy products and culled animals. But the beef cattle, hogs, or chickens fed on large operations are usually born elsewhere and marketed by other entities, as these grow-out farms specialize in single stages of livestock production. Producers are increasingly paid for the services that they provide, and not for the products that they sell.

This report analyzes the major shifts toward large-scale industrialized production systems in beef cattle, broilers, hogs, and milk, the four largest industries in the U.S. livestock sector. It focuses on the forces driving change and the major effects of those changes, drawing on findings from recent Economic Research Service (ERS) research that focuses on specific industries or practices. It does not assess the economics of organic or other alternative production systems, which have a growing but still small presence in the livestock sector.

Elements of Structural Change

Four elements distinguish the transformation of the livestock sector—increased farm size, changes in production technologies, increased enterprise specialization, and tighter vertical coordination between the stages of production. This report emphasizes farm size, with secondary attention to the other factors.

Most livestock are now fed in confined conditions in a barn, house, or fenced lot. Successful confinement feeding required a series of technological developments. The animals are bred to gain weight or produce milk efficiently, while also yielding specific meat or milk characteristics. Feed milling and delivery is automated, and herds and flocks are often grouped according to age and other characteristics and provided with feeds that are especially formulated for the group.

Another important feature of structural change is specialization. Some large farms produce only a single commodity, such as dairy farms that produce only milk or hog birthing operations that produce only nursery pigs, with no crop production. But such highly specialized operations are still the exception. Most large livestock operations also produce crops, but they increasingly specialize in a single stage of livestock production, such as hog finishing. Many of these operations may also loosen the links among their

different commodity enterprises; for example, a grain and hog farm may sell its grain and purchase the feed provided to its hogs.

Today's livestock farms are increasingly reliant on contracts and other agreements to govern the links between production stages. Traditionally, farmers relied on cash markets as the primary mechanism for organizing production. They borrowed money for input expenses from lenders, raised their livestock to market weight, and sold livestock and livestock products to processors for a price determined at the time of sale.

More formal and long-term contractual relationships now cover over half of all livestock production (MacDonald and Korb, 2008). Some contracts commit processors and farmers to a specific volume of production to be delivered over time, with pricing formulas based upon product quality, volumes, and market conditions. Other arrangements pay farmers a fee for growing livestock provided by the contractor. Still others specify joint livestock ownership and financing between a farmer and contractor.

Causes and Effects of the Transformation

New technologies, which underpin modern livestock agriculture, have also driven the growth in farm size. Just as a single family can now farm far more acres than in the past, with greater yields, so too can a single family raise far more animals or poultry and realize greater yields of meat or milk.

The enabling technologies are mechanical, biological, and chemical. Larger and faster equipment allows a single producer to till, seed, fertilize, spray, or harvest more acres; to house and feed more livestock or poultry; or to milk more cows in a single day. Improvements in animal breeding have led to larger animals that gain more weight or produce more milk for a given amount of feed and labor, just as improvements in seeds have done for crop productivity. Chemical fertilizers and herbicides have increased the amount of feed that can be produced, while animal pharmaceuticals reduce mortality and increase meat or milk yields under the same level of inputs.

Many large farm businesses are run by extended families of several generations, siblings, or cousins. Others may be managed by several unrelated business partners. Larger management teams allow individual operators to specialize in crop production, herd management, or marketing, so this too can lead to increases in farm size. Improvements in information technology have facilitated the management of large-scale field operations, herd performance, and finances.

New technologies often reduce costs directly, by allowing more meat and milk to be produced for a given amount of land, feed, labor, and capital. But the new technologies also create scale economies, which reduce costs more for larger operations. As a result, larger farms realize higher profits, on average, which provides a strong incentive for operators to grow larger. In turn, lower industrywide farm costs lead to lower prices for farm commodities. Lower prices can squeeze smaller farms with higher costs, causing many to exit, to grow, or to explore niche markets for differentiated products. Lower commodity prices lead in turn to lower retail food prices, such

that the benefits from technological improvements and larger farms flow to consumers.

While the transformation benefits society via lower food prices, it is not without costs. Large confined herds concentrate large quantities of manure, which must be removed from housing facilities, stored, and then moved to and spread on crop and pasture land. Animal manure contains nutrients like nitrogen, phosphorus, and potassium, and can therefore replace commercial fertilizers. But if not properly managed, manure can pose environmental risks. Excess nutrients do not contribute to further crop growth, but instead may damage air and water resources. Manure also contains bacterial pathogens that can pose direct threats to animal and human health.

Another environmental concern over increased scale is the widespread use of antibiotics. Large livestock operations tend to use animal antibiotics more intensively than smaller operations, as a way to control the spread of animal diseases and to promote faster growth. Antibiotics may enter natural resources through manure, and excessive use may contribute to increased resistance to antibiotics among animal and human pathogens.

Terminology: CAFOs and Large Livestock Operations

The environmental risks associated with the transformation of animal agriculture have led to ongoing discussion over the appropriate legal and regulatory responses to the risks. The farms that are the focus of this report are referred to as CAFOs (concentrated animal feeding operations) in those discussions, and the term is now in wide use.

In the U.S. Environmental Protection Agency's (EPA) designation, a CAFO is an animal feeding operation (AFO) that has been designated as a point source of pollutants. An AFO is a lot or facility where animals are confined and fed for 45 days or more in any 12-month period, and where crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any part of the lot or facility. The key elements in the definition are that the animals are confined; that they are fed, rather than grazed on grass or other vegetation; and that the "facility" refers to a structure, and not to an entire farm.

CAFOs are further defined by size. Large CAFOs are defined by animal inventories—at least 700 dairy cattle, 1,000 beef cattle, 2,500 pigs if they weigh over 55 pounds or 10,000 if they do not, and 30,000 broilers if the AFO has a liquid manure handling system or 125,000 if it does not. Medium-size CAFOs fall within intermediate size ranges and discharge wastewater or manure to surface waters, while small CAFOs are below the medium-size threshold but are designated by local permitting authorities as significant contributors of pollutants.¹

The EPA's definition of a CAFO captures key elements of the transformations described above—a production process that concentrates large numbers of animals in relatively small and confined spaces, and that substitutes structures and equipment (for feeding, temperature controls, and manure management) for land and labor. While the EPA has a precise definition for a CAFO, the term is now used broadly and interchangeably with terms like industrial-

¹ The lower bound threshold for medium CAFOs is 200 dairy cows, 300 beef cattle, 750 pigs if they weigh more than 55 pounds and 3,000 if they don't, and 9,000 broilers on those AFOs with liquid manure handling systems (37,500 otherwise).

ized agriculture or factory farms to refer to a production process that features confined feeding of large herds or flocks (Pew Commission, 2008; Union of Concerned Scientists, 2008; Starmer and Wise, 2007).

Data To Analyze the Transformation

We detail structural change with data from two large farm-level USDA databases that provide a unique and highly detailed picture of livestock agriculture in the United States. One is the census of agriculture, conducted every 5 years by USDA's National Agricultural Statistics Service (NASS). The census is an indepth and comprehensive source of information on changes in farm size, specialization, and location, and we utilize publicly available census data as well as confidential farm-level census records from the period covering 1982-2002.

The second data source is the Agricultural Resource Management Survey (ARMS), an annual survey of U.S. farms that links farm financial and production data, farm marketing and production practices, and farm household characteristics and finances. ARMS has several versions. Two focus on all farm types: a personally enumerated version (#1) that provides detailed whole-farm data and a shorter mail version (#5). Other enumerated versions target large, representative samples of producers of specific commodities; they include the whole-farm and farm household questions in version 5, but also include detailed questions on the expenses, revenues, equipment and structures, production practices, and contractual and marketing relationships associated with the commodity under study. Commodity versions are directed to producers in leading States—those that collectively account for 90 percent of production—and focus on operations whose livestock or poultry inventories exceed threshold levels (10 cows, 25 pigs, 1,000 broilers).

We use data from a 2006 ARMS broiler survey, dairy surveys from 2000 and 2005, and hog surveys from 1992, 1998, and 2004.² There have been no fed-cattle versions of ARMS because the concentrated nature of the industry does not lend itself to the sampling strategy used in the commodity versions.³ As a result, our analyses of fed cattle rely solely on other USDA sources, such as census records and NASS *Cattle on Feed* reports. Because of the coverage of our data sources, we emphasize developments since 1980, with some background information on earlier developments drawn from ERS reports and other studies.

² The reference year refers to the year of the data; that is, the 2004 survey was administered in early 2005, and obtained data for 2004. The 2004 ARMS hog version collected data from 1,168 producers in 19 States. The 2005 dairy version covered 1,462 farms in 24 States. The 2006 broiler version covered 1,568 farms in 17 States.

³ ARMS commodity versions select representative random samples of producers of the commodity, and livestock and poultry versions have had 800-1,680 producers in a sample. But since only about 260 feedlots account for most fed-cattle production, a useful survey would need to obtain participation from nearly all major feedlots.